noting the fall of pressure necessary to raise the pen to the highest point recorded. The time at which the instrument entered the cloud, at 1.58 p. m., is shown by the rise in humidity at that hour, and the time the instrument passed above the clouds is shown by the rapid fall of the humidity between 3 and 4 p. m. As the kites were drawn down, the cloud was again entered, at about 5.30 p. m.; the instrument was left at this height until 8 p. m. The time at which the weather cleared is shown by a decided fall in humidity at 7 p. m. The temperature at the highest point was about 20.2° F., or about 26° lower than the temperature at the observatory. The average strain on the line for several hours, when at the highest elevation, was between 60 and 100 pounds, but after 6 p. m. it became less, and for the entire ascent was between 30 and 55 pounds. A hand windlass was used for winding in the line. Three men—Messrs. Clayton, Sweetland, and myself—did the whole of the work without assistance.

## PHENOLOGY.

A general summary of the literature of phenology showing somewhat fully the results already obtained by the study of a great mass of observations was submitted by the Editor in a report of June 30, 1891, but this seems to have formed a volume too bulky for publication. Subsequently a report was made by Prof. L. H. Bailey, of the College of Agriculture in Cornell University, on the general subject of phenology. As the publication of the latter report has been delayed it is thought best to present, through the medium of the MONTHLY WEATHER REVIEW, the following portion which suggests useful work for voluntary observers. It is hoped that the present brief instructions will suffice to stimulate the interest in this subject which would seem to have flagged somewhat in America during the past twenty-five years. As the conservative botanists still retain the use of the Latin language and the reckoning of longitudes from Ferro, 18° 07′ west of Greenwich, the Editor has not ventured to alter these matters.—C. A.

### INSTRUCTIONS FOR TAKING PHENOLOGICAL OBSERVATIONS.

By Prof. L. H. BAILEY.

Phenological observations are of two general types, although there is no invariable difference between them; those which record simply the external features of the passing life of plants and animals, and those which attempt to discover or construct some vital connection between life events and climatal environment. The one is concerned chiefly with mere observations, the other with experiment and the philosophy of life courses. While the recording of life-dates may serve either purpose, it must be left to the trained scientist to make the comparisons in the deeper studies of the mutual relationships of climate and periodical phenomena. At the present time I wish simply to indicate the practical methods to be pursued in the taking of notes that shall have permanent value.

Of first importance is the purpose which the observer has in mind. This purpose should be restricted to a definite line of inquiry, and its theme, if it be phenological, should be climate rather than natural history. Let him take one or more of the following subjects:

1. To determine the general oncoming of spring.
2. To determine the fitful or variable features of spring.
3. To determine the epoch of the full activity of the advancing season.
4. To determine the active physiological epoch of the year.
5. To determine the maturation of the season.
6. To determine the oncoming of the decline of fall.
7. To determine the approach of winter.
8. To determine the features of the winter epoch.
9. To determine the fleeting or fugitive epochs of the year.

It is evident that any miscellaneous series of observations will satisfy none of these purposes, unless, possibly, the last. Such plants must be selected as will give unequivocal periods, and which are convenient for observation year by year. The observer must feel that records are valuable in proportion to the number of years over which they extend. Except in determining fugitive epochs (No. 9), observations of a single season alone have little value. Hoffmann's five tests of phenological observations are as follows:[1]

1. As broad a distribution as possible of the given species selected for observation.
2. Ease and certainty of identifying the definite phases which are to be observed.
3. The utility of the observations as regards biological questions, such as the vegetative periods, time of ripening, etc.
4. Representation of the entire period of vegetation.
5. Consideration of those species which are found in almost all published observations, and especially of those whose development is not influenced by momentary or accidental circumstances, as is the dandelion.

Generally speaking, the events which determine the epochs 1, 3, 4, 5, and 6 should be observed upon a definite and well chosen set of plants of limited number, and it is important that the dates should generally represent the average epoch, and not the very first bloom or leaf upon some individual early plant. In recording the leafing of plants, the date chosen should be that upon which the leaves are seen to be spread open or expanded so that the upper surface is visible, and not the mere bursting or unrolling of the bud. Hoffman's "Scheme for phenological observations" is essentially that proposed by Linnæus:

*a.* Upper surface of the leaf first visible or spread open.
*b.* First blossom open.
*c.* First fruit ripe.
*d.* All leaves, or more than half of them, colored.

One should also be careful to select a typical or average plant for observation, and one which is not unduly exposed either to heat or cold, moisture or dryness. The observer should be careful to state if the plant is in wild or cultivated grounds. Most authorities discourage the taking of dates from the same individual plant year after year, although this is one of the most accurate means of determining variations in local climate; but it may not represent the average of a wide range. The safest plan is to take notes upon two or three typical individuals and then to average the observations. The leafing period of some diœcious plants differs between the two sexes. Britton has found,[2] for instance, that "the female in diœcious plants appears to hold its foliage longer than the male." This was "very strongly marked in *Ailanthus glandulosus*, *Acer saccharinum* and *Acer rubrum*,[3] and *Salix alba* and *Salix discolor*, but not in *Populus*." Woods[4] observed, however, that in the cottonwood "the female tree generally drops its leaves first and leafs out last." The observer should also consider that his observations of blooming and leafing correct or check each other, and that, therefore, both epochs should be recorded in the same specimens, so far as possible. Observations should be made every day.

In publishing phenological observations which are taken at a single station, the species of plants should be arranged according to the dates of the events, beginning with the earliest, and not alphabetically. That is, it is generally best to devote the first column to dates, the second to names of the plants, and the third to the events.

The proper method of securing phenological records is to put the matter in the hands of a single person or office for

[1] Hermann Hoffmann, Phanologische Beobachtungen aus den Jahren, 1879-1882, p. 141.
[2] Bull. Torr. Bot. Club, vi. 211.
[3] The maples are not strictly diœcious, but polygamo-diœcious.
[4] A. F. Woods, Bull. 11, Nebr. Exp. Sta.

each State, or geographical region, or better still, for the entire United States. The best results can be secured under direction from a central office, connected with the Weather Bureau, at Washington. This office should determine the species of plants to be observed in every geographical region, and should distribute printed blanks upon which the observations are to be recorded. The records would then be uniform and comparable, and results of inestimable value would soon be obtained. There is really no possibility of arriving at conclusions of permanent value from any study of the scattered and disconnected observations thus far made in this country.

The methods of the German phenologists illustrate the great value which they attach to uniformity of observation. Hoffmann and Ihne recommend observers to select their plants from the following list, and to make the returns upon this model:

Feb. 10. *Corylus Avellana*, Stäuben der Antheren (shedding of the pollen).
Apr. 10. *Aesculus Hippocastanum*, B. O.
13. *Ribes rubrum*, e. B.
17. *Ribes aurem*, e. B.
17. *Betula alba*, e. B., Stäuben der Antheren (shedding of the pollen).
18. *Prunus Avium*, e. B.
19. *Prunus spinosa*, e. B.
19. *Betula alba*, B. O. s.
22. *Prunus Cerasus*, e. B.
23. *Prunus Padus*, e. B.
23. *Pyrus communis*, e. B.
25. *Fagus sylvatica*, B. O. s.
28. *Pyrus Malus*, e. B.
May 1. *Quercus pedunculata*, B. O. s.
3. *Lonicera Tatarica*, e. B.
4. *Syringa vulgaris*, e. B.
4. *Fagus sylvatica*, Buchwald grün, allgemeine Belaubung (beech woods green, generally in leaf).
4. *Narcissus poeticus*, e. B.
7. *Aesculus Hippocastanum*, e. B.
9. *Crataegus Oxyacantha*, e. B.
12. *Spartium scoparium*, e. B.
14. *Quercus pedunculata*, Eichwald grün, allgemeine Belaubung (oak woods green, generally in leaf).
14. *Cytisus Laburnum*, e. B.
16. *Cydonia vulgaris*, e. B.
16. *Sorbus Aucuparia*, e. B.
28. *Sambucus nigra*, e. B.
28. *Secale cereale hibernum*, e. B. (Winter rye.)
28. *Atropa Belladonna*, e. B.
June 1. *Symphoricarpos racemosa*, e. B.
2. *Rubus Idaeus*, e. B.
2. *Salvia officinalis*, e. B.
5. *Cornus sanguinea*, e. B.
14. *Vitis vinifera*, e. B.
20. *Ribes rubrum*, e. Fr.
21. *Ligustrum vulgare*, e. B.
22. *Tilia grandifolia*, e. B.
26. *Lonicera Tataricum*, e. Fr.
30. *Lilium candidum*, e. B.
July 4. *Rubus Idaeus*, e. Fr.
5. *Ribes aureum*, e. Fr.
19. *Secale cereale hibernum*, Ernte-anfang (beginning of harvest).
30. *Sorbus Aucuparia*, e. Fr.
30. *Symphoricarpos racemosa*, e. Fr.
Aug. 1. *Atropa Belladonna*, e. Fr.
11. *Sambucus nigra*, e. Fr.
24. *Cornus sanguinea*, e. Fr.
Sept. 9. *Ligustrum vulgare*, e. Fr.
16. *Aesculus Hippocastanum*, e. Fr.
Oct. 10. *Aesculus Hippocastanum*, a. L. V.
13. *Betula alba*, a. L. V.
15. *Fague sylvatica*, a. L. V.
20. *Quercus pedunculata*, a. L. V.

The abbreviations following the names represent the life events, and are as follows: B. O. or B. O. s., surfaces of leaves first visible (erste Blattoberflachen sichtbar); e. B., or b., first flower opens (erste Bluthen offen); e. Fr., or f., first fruit ripe in the case of soft fruits, or definitely colored in the case of seeds in capsules (erste Frucht reif, definitiv verfarbt); a. L. V. or L. V., leaves all, or more than half of them, colored (allgemeine Laubverfärbung, über die Hälfte der Blätter verfärbt).

In publishing the records of the various observers, Hoffmann[1] first inserts the records for Giessen, his own station, as a basis of comparison. The method of this publication will interest the reader, and I insert an example. The abbreviations which I have just given are used in these records. The Roman numerals refer to the months. At the close of each record, the average blooming season is compared with that of Giessen, by computing it in the following manner with the April epoch of that place:

*Reduction to the April blooming at Giessen.*

| | Average April blooming. | | Days after Giessen. |
|---|---|---|---|
| | Giessen. | St. Paul. | |
| Betula alba b | 17 IV | 18 IV | −1 |
| Prunus avium b | 18 IV | 19 IV | −1 |
| Prunus Cerasus b | 22 IV | 26 IV | −4 |
| Prunus Padus b | 23 IV | 28 IV | −5 |
| Prunus spinosa b | 19 IV | 19 IV | 0 |
| Pyrus communis b | 23 IV | 27 IV | −4 |
| Pyrus Malus b | 28 IV | 2 V | −4 |
| Ribes aureum b | 17 IV | ........ | ........ |
| Ribes rubrum b | 13 IV | 17 IV | −4 |
| Average | 20 IV | ........ | −3 |

| | Average, 1882. | | Days after Giessen. |
|---|---|---|---|
| | Giessen. | Berleburg. | |
| Betula alba b | ........ | ........ | ........ |
| Prunus avium b | 3 IV | 20 IV | −17 |
| Prunus Cerasus b | 9 IV | 27 IV | −18 |
| Prunus Padus b | 10 IV | 28 IV | −18 |
| Prunus spinosa b | 31 III | 25 IV | −25 |
| Pyrus communis b | 9 IV | 24 IV | −15 |
| Pyrus Malus b | 21 IV | 15 IV | −24 |
| Ribes aureum b | ........ | ........ | ........ |
| Ribes rubrum b | 31 III | 19 IV | −19 |
| Average | ........ | ........ | −19 |

The tabulation of the records proceeds as follows (the additional abbreviations are, J. in the parenthesis stands for years; (19 J.) means 19 years of observation; W. means Wald allgemeine Belaubung, *i. e.* forests generally in leaf; Apr. Red. means April reduction, as deduced from the comparison of all the springtime observations with those at Giessen):

*Example of a summary of a long record.*

GIESSEN.—N. 50° 35′, E., from Ferro, 26° 20′; 160 meters above sea; mean temperature 6.7° R. (8.4° C.); observer, H. Hoffmann.

Average, 1845–1883.——*Aesculus Hippocastanum* B. O. 10 IV (19 J.); b. 7 V (29 J.); f. 16 IX (29 J.); L. V. 10 X (25 J.).——*Atropa Belladonna* b. 28 V (24 J.); f. 1 VIII (17 J.).——*Betula alba* b. 17 IV (15 J.); B. O. 19 IV (5 J.); L. V. 13 X (10 J.).——*Cornus sanguinea* b. 5 VI (9 J.); f. 24 VIII (2 J.).——*Corylus Avellana* b. 10 II (35 J.).——*Crate-*

[1] The student should also consult the method pursued in Quarterly Journal of the Royal Meteorological Society. Consult Preston's lists in volume for 1884, and previous.

*gus Oxyacantha* b. 9 V (27 J.).——*Cydonia vulgaris* b. 16 V (16 J.).——*Cytisus Laburnum* b. 14 V. (21 J.).——*Fagus sylvatica* B. O. 25 IV (18 J.); W. 4 V (35 J.); L. V. 15 X (27 J.).——*Ligustrum vulgare* b. 21 VI (10 J.); f. 9 IX (3 J.).——*Lilium candidum* b. 30 VI ( 26 J.).——*Lonicera Tatarica* b. 3 V (11 J.); f. 26 VI (4 J.).——*Narcissus poeticus* b. 4 V (30 J.).——*Prunus Avium* b. 18 IV (30 J.); *Cerasus* b. 22 IV (27 J.).——*Padus* 23 IV (25 J.).——*Prunus spinosa* b. 19 IV (26 J.).——*Pyrus communis* b. 23 IV (30 J.).——*Malus* b. 28 IV (30 J.).——*Quercus pedunculata* B. O. 1 V (17 J.); W. 14 V (21 J.); L. V. 20 X (16 J.).——*Ribes aureum* b. 17 IV (11 J.); f. 5 VII (4 J.).——*Ribes rubrum* b 13 IV (25 J.); f. 20 VI (31 J.).——*Rubus Idæus* b. 2 VI (3 J.); f. 4 VII (6 J.).——*Salvia officinalis* b. 2 VI (3 J.).——*Sambucus nigra* b. 28 V (30 J.); f. 11 VIII (30 J.).——*Secale cereale hybernum* b 28 V (30 J.); f. becoming mealy 10 VII (8 J.); harvest begins 19 VII (29 J.).——*Sorbus Aucuparia* b 16 V (18 J.); f. 30 VII (18 J.).——*Spartium scoparium* b. 12 V (14 J.).——*Symphoricarpos racemosa* b. 1 VI (3 J.); f. 30 VII (4 J.).——*Syringa vulgaris* b. 4 V (29 J.).——*Tilia Europæa* (*a*) *grandifolia* b 22 VI (21 J.); (*b*) *parvifolia* b. 27 VI (17 J.).——*Vitus vinifera* b. 14 VI (31 J.).

*Example of a record for one year.*

APELDOORN, HOLLAND.—Lat. 52° 13′, Long. 23° 36′; altitude ....... Kok Ankersmit, H. O., 1882.——Aesc. b. 28 IV; f. 30 VIII.——Atro. b. 31 V.——Crat. 4 V.——Cyd. 2 V.——Cyt. 5 V.——Lil. 1 VII.——Lon. b. 24 IV; f. 28 VI.——Narc. 29 IV.——Prun av. 5 IV——Cer. 7 IV.——Pad. 14 IV; spin. 8 IV.——Pyr. co. 10 IV; Mal. 21 IV.——Rib. ru. b. 31 III; f. 22 VI.——Samb. b. 27 V; f. 30 VIII.——Sec. b. 27 V.——Sorb. b. 3 V; f. 5 VIII.——Spart. 26 IV.——Syr. 5 V.——Til. gr. 24 VI.——Vit. 10 VI.——Apr. Red. two days after Giessen.

It will be seen that these records of Hoffmann aim to determine the date epochs of the advancing season. Linsser, who takes a more philosophical view of the problem, and considers it in relation to ultimate climatological effects, tabulates the average results of many observations in connection with the temperature or physiological constants. I give an example. The various columns in the record are as follows: 1, station; 2, total annual accumulated temperature, divided, for convenience, by 1,000; 3, mean day of leafing; 4, number of observations; 5, accumulated temperature for the event; 6, fractional or proportional part of the annual total; *e. g.*, $\frac{453}{4300} = 0.11$. The other divisions for blooming and ripening of fruit, respectively, follow the same order, omitting, of course, the station and the annual total accumulated temperature.

*Prunus Padua*, 27 *Stations with* 490 *Observations*.
(From Linsser's second paper, page 23.)

| Stations. | | Leafing. | | | | Blooming. | | | | Ripening. | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| | | | | ° | | | | ° | | | | ° | |
| Dijon | 4.3 | 9 Apr. | 8 | 453 | 0.11 | 30 Apr. | 8 | 708 | 0.17 | 14 July. | 7 | 2,053 | 0.48 |
| Heidelberg | 3.9 | ........ | ... | .... | ..... | 6 May. | 6 | 696 | 0.18 | ........ | ... | ...... | .... |
| Paris | 3.9 | ........ | ... | .... | ..... | 27 Apr. | 1 | 626 | 0.16 | ........ | ... | ...... | .... |
| Namur | 3.9 | 2 Apr. | 13 | 345 | 0.09 | 28 Apr. | 15 | 594 | 0.15 | ........ | ... | ...... | .... |
| Ghent | 3.8 | 4 Apr. | 6 | 335 | 0.09 | 28 Apr. | 6 | 566 | 0.15 | 6 Aug. | 1 | 2,250 | 0.59 |
| Ostende | 3.7 | 15 Apr. | 13 | 464 | 0.12 | 1 May. | 12 | 628 | 0.17 | 3 Aug. | 11 | 2,072 | 0.55 |
| Brüssel | 3.7 | 16 Apr. | 13 | 408 | 0.11 | 11 May. | 17 | 681 | 0.18 | ........ | ... | ...... | .... |
| Braunschweig | 3.4 | ........ | ... | .... | ..... | 2 May. | 30 | 544 | 0.16 | ........ | ... | ...... | .... |
| Stavelot | 3.2 | ........ | ... | .... | ..... | 6 May. | 9 | 423 | 0.13 | ........ | ... | ...... | .... |
| München | 3.1 | 27 Apr. | 9 | 205 | 0.10 | 4 May. | 8 | 375 | 0.12 | 12 Aug. | 8 | 2,026 | 0.65 |
| Tübingen | 3.1 | 16 Apr. | 1 | 274 | 0.09 | 3 May. | 10 | 444 | 0.14 | ........ | ... | ...... | .... |
| Stettin | 3.1 | 14 Apr. | 7 | 183 | 0.06 | 5 May. | 20 | 375 | 0.12 | 13 July. | 20 | 1,433 | 0.46 |
| Kreuzburg | 3.0 | ........ | ... | .... | .... | 5 May. | 4 | 323 | 0.11 | ........ | ... | ...... | .... |
| Görlitz | 3.0 | 28 Apr. | 2 | 280 | 0.09 | 7 May. | 11 | 366 | 0.12 | ........ | ... | ...... | .... |
| Orel | 2.8 | 3 May. | 3 | 144 | 0.05 | 16 May. | 3 | 276 | 0.10 | 17 July. | 1 | 1,324 | 0.47 |
| Moskau | 2.6 | 11 May. | 3 | 184 | 0.07 | 23 May. | 6 | 319 | 0.12 | 18 Aug. | 3 | 1,880 | 0.71 |
| Riga | 2.6 | 12 May. | 4 | 216 | 0.08 | 22 May. | 6 | 321 | 0.12 | 14 July. | 2 | 1,154 | 0.45 |
| Christiania | 2.4 | 11 May. | 11 | 191 | 0.08 | 27 May. | 10 | 359 | 0.15 | ........ | ... | ...... | .... |
| Abo | 2.3 | 23 May. | 2 | 260 | 0.11 | 2 June | 19 | 374 | 0.16 | 4 Aug. | 3 | 1,372 | 0.60 |
| St. Petersburg | 2.3 | 9 May. | 6 | 111 | 0.05 | 2 June | 14 | 348 | 0.15 | 12 Aug. | 6 | 1,475 | 0.65 |
| Carlo | 1.9 | 28 May. | 13 | 179 | 0.09 | 16 June | 13 | 386 | 0.20 | ........ | ... | ...... | .... |

The value of the accumulated temperatures is only relative or comparative, not absolute. It does not matter so much how they are obtained, as that they shall all be secured from uniform data. They are generally made by adding up the customary three daily readings of the thermometer. The total accumulated temperature, then, may be the sum of 1,095 (365 × 3) readings of the thermometer, or any other number of readings which any central authority may determine upon. The accumulated temperature of any life event may, for convenience, be reckoned as that part of the annual accumulated temperature which accumulates between January 1 and the date of the event.

Nothing now remains, I think, for the instruction of the observer, but to give a list of the plants which he shall observe. Unfortunately, this is no easy task for a country so large as the United States. As a general statement, it may be said that the observer should select a dozen species which are the most abundant, the most generally distributed over a wide area, and which have the most marked flowers and emphatic periods of bloom and other epochs. The staple cultivated fruits answer these purposes well, as apples, pears, plums, cherries, quinces, raspberries, blackberries, strawberries; and for the sudden moods of early spring, the peach is excellent. Forest trees usually have such inconspicuous bloom that no one but a botanist is likely to take the observation at exactly the proper time. This is particularly true of those which bear catkins, for these organs are not only inconspicuous, but they often increase in length for several or many days, and the period is therefore indefinite. Trees and shrubs are usually better than herbs for general records, as they commonly have more definite seasons and they are less modified by incidental circumstances. Many plants that are well adapted to the purposes of phenological records must be omitted because the general observer is unable to accurately determine the particular species to which they belong. This is notably the case with our thorn trees, or *Cratægus*, the species of which are difficult of analysis, even to the botanist.

For the fugitive or abnormal epochs of the year, as "warm spells" in winter or spring, or "late falls," and the killing frosts of fall and late spring, the observer must consider whatever species come in his way. And here is the chief value of the dandelion in phenological records—it should not be included in any general scheme of notes. There is the greatest temptation to record the blooming of the very earliest spring flowers, as mayflower or epigea, hepatica, erigenia, dandelion, willows, crocus, and the like. This is well, and the records should be made, as showing the first burst of spring; but these records should not be mixed in with those designed to show the general onward course of the seasons.

It is impossible to specify the plants which are best adapted to phenological notes over so wide and various a territory as ours. Much will depend, also, upon the training of the observers. If the records could be made by botanists, many species could be included which other observers could not be trusted to distinguish from closely related species. Observers who are doubtful as to the proper name of a plant from which records are taken should send a botanical specimen of it to a competent person; and whenever any central office or collator notices aberrant dates in suspected species he should call for botanical specimens. Nearly all phenological records in this country have been made by botanists, and they are printed in the botanical or natural history publications. This means that the subject has been considered to be a biological one rather than a climatological one. I hope that this attitude may now be shifted, so as to place phenological records with the science of climate rather than with the science of organisms. The periods of animals and plants are often of great value in determining specific characters, but this use of them has only a remote connection with the proper science of phenology. I shall not attempt, therefore, to give a list of suitable plants for the whole country, but will mention those which appear to me to be most valuable for the main phenological observations and for the general run of observers in New York and New England, it being understood that the observer shall designate, as far as possible, the particular variety which he has recorded in the case of cultivated plants:[1]

[1] The student may be interested in consulting the list of plants in Magnuss' Tabellarische Zusammenstellung Phanologischer Beobachtungen, 1893.

Apple.
Pear.
Quince.
Plum.
Sweet cherry.
Sour cherry.
Peach.
Choke cherry (*Prunus Virginiana*).
Wild black cherry (*Prunus serotina*).
Japanese or flowering quince (*Pyrus Japonica*).
Cultivated raspberry.
Cultivated blackberry.
Cultivated strawberry.
Lilac.
Mock orange syringa (*Philadelphus coronarius*).
Horse chestnut.
Red-pith elder (*Sambucus racemosa*).
Common elder (*Sambucus canadensis*).
Flowering dogwood (*Cornus florida*).
Native basswood.
Native chestnut.
Privet or prim (*Ligustrum vulgare*).
Red currant.
Cultivated grape.

In making the records, the events to be noted are those specified by Hoffmann, taken from normal or average plants—surface of leaf first visible; first flower open; first fruit ripe or full colored; half or more of the leaves full colored. To these should probably be added the date of nearly complete defoliation for those species whose leaves color some time before they fall. All aberrant or unusual flowering seasons should be recorded, but they should be distinctly marked in order that they may not be confounded with the normal events. All sudden meteorological changes which noticeably affect the plants under observation should be noted, as frosts in fall and spring, and high winds when defoliation is taking place. In short, the observer should endeavor to make his notes in such manner that they shall record the entire movement of the seasons.

Persons who spend their summers in resorts at the seacoast, in the mountains, or elsewhere, can make useful records, provided they visit the same places year by year. They can select a few typical plants, and observe their condititions at time of arrival and departure. At the same time, they can often make records of the progress of harvests of hay and grain, and other staple crops.

## PROGRESSIVE MOVEMENT OF THUNDERSTORMS.

By A. J. HENRY (dated October 28, 1896).

In a letter of September 24, Mr. J. E. Lanouette, observer, Weather Bureau, in charge of station at Tampa, Fla., says:

I have the honor to ask for some information in regard to the prevailing direction of thunderstorms at other stations on the Gulf Coast. Thus far this summer the prevailing direction at this station has been from the southeast to northwest.

During the four years and more that I was on duty at Titusville the thunderstorms invariably developed either in the southwest, west, or northwest.

I remember but one instance where the storm developed in a quadrant different from those mentioned, and that was on the coast to the northeast of Titusville.

At other stations where I have been on duty, a thunderstorm moving from the southeast to northwest would be an abnormal direction, but here it seems to be normal.

This subject has at different times been discussed in this office, and while the general opinion favors this direction as due to the greater amount of vapor present in the Gulf, it would be interesting to get the views of the Bureau on this point, for if this theory is correct it would explain the eastern movement on the east coast toward the Atlantic, and the directions at Corpus Christi and Galveston should be toward the Gulf.



Key West, being uninfluenced by the same conditions which are present on the main land, should show a direction different from any of those mentioned.

In this connection I would say that the cloud movement here is very sluggish, more so than at any station where I have served.

The following reply to the above has been made and will, it is hoped, stimulate further study of this subject by others.

The questions propounded by Observer Lanouette are of no little interest since they invite a study of thunderstorms in the region of greatest frequency in the United States, where also the conditions of formation are somewhat different from those which obtain in more northern latitudes.

Tampa lies near the dividing line between the general westerly and easterly motions of the air strata in which thunderstorms originate and at a considerable distance south of the center of cyclonic systems passing eastward. In fact it would seem there is no simple relation between the position of a cyclonic system farther north or northwestward and the occurrence of thunderstorms in the Gulf States and Florida Peninsula. Moreover, the fact that the maximum frequency of thunderstorms occurs during July and August when the general easterly movement of the atmosphere is more or less feeble and the tendency to the formation of cyclones less pronounced, seems to warrant the belief that cyclonic influence has little share in the development of thunderstorms in this region. It is also believed that the thunderstorms experienced in the Florida Peninsula are less violent than those of the Mississippi and Ohio valleys. Additional information upon this point, however, is desired.

The data of the subjoined table show the direction of movement of thunderstorms at selected stations on the Gulf and South Atlantic coasts. For the sake of comparison the values for each of the eight principal points of the compass have been expressed as a percentage of the whole number of storms observed.

It is obvious that the general direction at the majority of the points selected is from some westerly quarter, the notable exception being Key West. The direction of motion at the latter station, as might be expected from its geographic position, is wholly different from that of the remaining stations, with the possible exception of Tampa. Key West lies well within the influence of the northeast trades at all times, and it is not surprising that the prevailing direction of thunderstorms should be toward a westerly quarter.

Tampa and Jupiter, the nearest stations to Key West, lie near the line of division between the prevailing easterly winds of the middle latitudes and the westerly winds of the Tropics, but on opposite sides of the peninsula. The direction of motion at Tampa is somewhat similar to that at Key West, but it is evident that the controlling conditions at Jupiter are essentially different from those which prevail at both Tampa and Key West.

The great majority of thunderstorms at Jupiter move from the southwest to the northeast—from the land to the ocean; the prevailing direction at Tampa is not so well marked, but it is evidently from the east and southeast—from the land to the ocean—as at Jupiter. The irregularity of movement at Tampa, as shown by the table, may be accounted for by assuming that the local circulation is at times within the influence of the general easterly drift of the atmosphere and again controlled by the westerly movement of the air within the Tropics. The more probable explanation, however, would seem to be that the movement of individual thunderstorms is controlled by the pressure distribution and other local influences.

Comparing the direction of progression on the two sides of the peninsula it is found that the majority of storms on either side approached from the landward side of the point of observation where the conditions of thunderstorm formation are most favorable.